NAVAL POSTGRADUATE SCHOOL
Monterey, California

ECE 3550   Fiber Optics Experiment 4   4/2002 Po

DATA LINK SYSTEM PERFORMANCE

Purpose: In this experiment we will measure and compute the system performance parameters for a simple digital fiber optic link.

Equipment:

General purpose test equipment (dual-trace scope, multimeter, signal generator)
Power supply (+5 volts)
Fiber optic data link (with HFBR-1402 Transmitter, HFBR-2402 Receiver, Siecor optical cable (with connectors))
Photodyne 2275XQ optical multimeter
Spec sheet for fiber optic link (at lab station)
Handheld infrared viewer
Digital camera

Procedure:

1. Figure 1 shows the digital transmitter circuit. The resistor R1 in series with the variable resistor VR1 controls the amount of current through the HFBR 1402 LED. Given the typical voltage drop and maximum forward current found in the HFBR 1402's specification sheet, calculate the value of the resistor R1 required to avoid exceeding the maximum current specified for the LED. (In this calculation, assume that VR1 has been adjusted to zero.) We will use a resistor with a value of 56 Ω in this circuit.
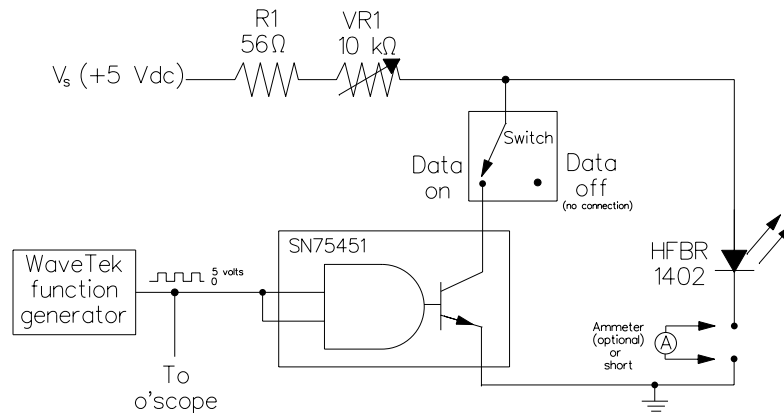

Figure 1: Digital transmitter circuit.

2. Apply 5 volts DC to the transmitter circuit. On the transmitter, set the switch at the top of the unit to the "DATA OFF" position. Remove the optical fiber and verify that the LED is operating using the IR viewer.

1

3. Connect the fiber to the transmitter. Attach the other end of the fiber to the optical multimeter. Measure, record, and plot the optical power in the fiber (in dBm or dBμ) vs. the DC current through the diode (as measured with the multimeter). (Adjust the potentiometer to control the DC current. Turn VR1 CCW to increase the current and CW to decrease the current.) This plot should be on semilog paper with the power on the linear axis and the current on the logarithmic axis. Why? (*Record and plot the data as you measure it in the lab for reference later in procedure.* Include a finished plot of this figure in your report.)

4. Connect the fiber cable to the receiver circuit, Fig. 2. Verify that 5 volts DC is applied to the receiver circuit and that the output is connected to Channel 2 of the oscilloscope. Using the variable resistor on the transmitter, find and measure the optical power level that causes the receiver output to change level (i.e., where the output pulse is midway between its extreme values) – this is the "optical threshold power". (Note that the receiver inverts the output signal from the input signal.)
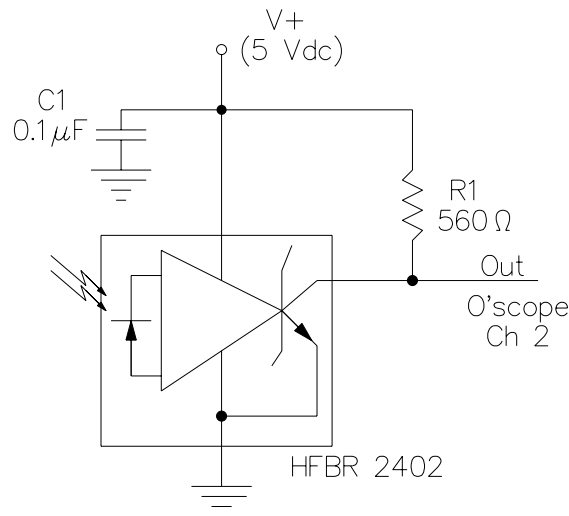

Figure 2: Digital receiver circuit.

5. Return the optical power to an intermediate level by adjusting VR1 at the transmitter between 50 and 60 mA. Note the value of the DC diode current. Set the function generator to a TTL-valued square wave (0 to 5 volts) with a nominal frequency of 100 kHz. Connect this signal to the transmitter and set the switch at the top of the unit to the DATA ON position. Note the change in the value of the DC diode current. Observe proper operation of the link by obtaining an inverted signal on Channel 2 of the oscilloscope. (This may require some adjustment of your transmitter output power.) Record an image of the scope traces with the digital camera for inclusion in your report.

6. Using VR1, adjust the transmitter's optical power level to find the minimum power at the detector required to ensure proper operation of the data link, i.e., where the circuit can just barely distinguish a logical "1"). Record an image of the scope traces.

Parameter	Siecor cable	HP–3021 cable
Attenuation	2.4 dB/km @ 850 nm	5.5 @ 850 nm
NA	0.2	0.3
BW–distance	600 MHz-km	40 MHz-km
	@ 850 nm	@ 850 nm
g	2	2
Diameters	50/125	100/140

Table 1: Specifications for fiber cables in hypothetical link.

7. The "system margin" of this data link can be defined as the difference between (1) the power at the fiber end at full drive current (in dBm) and (2) the optical threshold power that you measured in Step 4 (i.e., $M = P_{\text{T max}} - P_{\text{R threshold}}$). Compute the system margin for your link. Using the Siecor cable specs found in the table attached, compute the nominal expected link distance if the link is all fiber (i.e., no splices or connectors).

8. Suppose that we imagine inserting an intermediate cable between the transmitter and receiver as shown in Fig. 3 by breaking the Siecor cable and attaching connectors. If we were to connect the transmitter fiber to a HP cable (specifications for the fiber cables are found in Table 1), *calculate* the connector losses expected due to the NA mismatch. Due to fiber diameter mismatch? Due to reflections? Repeat for the connector between the intermediate fiber and the receiving fiber. How much HP fiber could we have between the connectors?
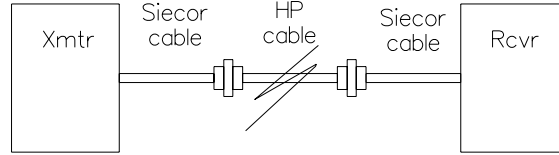

Figure 3: Hypothetical link with intermediate cable

9. Return the optical power level to its maximum value. Set the data rate to 200 kb/s and measure the fall time t_f and the rise time t_r of the output of the receiver. (Note that the scope face has the 10% and 90% points indicated with dotted lines. Proper use of the vertical [uncalibrated] scale multiplier factor and the scope cursors will simplify this measurement.) Record scope pictures of your measurements.

10. Increase the data rate. Describe the limiting factor (i.e., t_r or t_f) of the output. What is the maximum measured data rate of the link as used? Record a scope picture of the signals at the maximum data rate and at beyond the maximum rate.

Report: Submit a brief (but complete) report summarizing your observations. This report is due within one week of completing the laboratory exercise.